UNITED STATES PATENT APPLICATION

For

PARTIALLY REAL AND PARTIALLY SIMULATED MODULAR INTERACTIVE ENVIRONMENT

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PARTIALLY REAL AND PARTIALLY SIMULATED MODULAR INTERACTIVE ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of the filing date of U.S. provisional application, serial number 60/406,281, filed August 27, 2002, entitled "Immersive System of Digital Walls and Physical Props," the entire content of which is incorporated herein by reference.

BACKGROUND OF INVENTION

[0002] *Field of Invention*

[0003] This application relates to virtual reality systems, including virtual reality systems that simulate a real environment.

[0004] *Description of Related Art*

[0005] It is often helpful to simulate a real environment to test one or more individuals or to train them to better cope with the real environment.

[0006] Conducting the test or training in the real environment is often more realistic. However, it is also often impractical. The real environment might pose dangers to the individuals, such as in a hostage situation or the repair of a contaminated nuclear reactor. Failure of the individual to succeed with his effort in the real environment might also lead to catastrophic losses. The real environment might also not be readily accessible or available.

[0007] Mock-ups have been made as part of an effort to meet this need. Sometimes, however, the mock-ups take too long to create, cost too much money, are difficult to reconfigure, and/or are hard to transport. Mock-ups also sometimes lack a sense of realism.

[0008] The projection of images on screens has also been used. These presentations, however, also often lack realism. There is usually nothing real to touch or interact with, and the screen is often devoid of any surrounding context.

[0009] Head-mounted displays have also been used. Still, however, there is often nothing real to touch. These devices can also be heavy and seriously restrict movement.

BRIEF SUMMARY OF INVENTION

[0010] An interactive environment may be partially real and partially simulated. It may include a structure that is large enough to accommodate an individual both before and after the individual takes a plurality of displacement steps within the structure. At least one real, three-dimensional object may be positioned within the structure, the real object and the structure cooperating to form a seamless and integrated scene. At least one computer-controlled display may be fixedly positioned within the scene such that each image displayed by the display appears to the individual to be real, three-dimensional and an integral and seamless part of the scene. At least one sensor may be configured to sense interaction between the individual and the scene. A processing system may be in communication with the sensor and the display and configured to deliver a sequence of images to the display, the content of which are a function of the interaction between the individual and the scene, including a plurality of displacement steps taken by the individual.

[0011] The display may be configured and positioned so as to appear to the individual to be an integrated and seamless part of the scene that is something other than a display. The display may be part of the structure.

[0012] The display may include a wall of the structure. One of the images may include an image of wall texture, and the processing system may be configured to deliver the image of the wall texture to the display.

[0013] A real, operable door may be positioned in front of the wall of the display.

[0014] A real window may be positioned in front of the wall of the display. The window may be operable such that it can be opened or closed. The window may include operable shutters.

[0015] The interactive environment may be configured to simulate a real environment having a similar structure, a similar real object and a scene beyond the structure. One

of the images may include an image of the scene beyond the structure. The interactive environment may include a real or virtual door or window. At least a portion of the display may be oriented within the opening of the door or window. The processing system may be configured to deliver the image of the scene beyond the similar structure to the display.

[0016] One or more of the images may be selected by the processing system from a library of images stored on an image storage device.

[0017] The interactive environment may be configured to simulate a real environment and one or more of the images may be captured from the real environment. The images that are captured from the real environment may be delivered by the processing system to the display in real time.

[0018] The structure, display and real object may be configured in the form of modules that releasably connect to and disconnect from one another to facilitate the assembly, disassembly, shipment and re-assembly of the interactive environment in various different configurations. A portion of the structure, the display or the real object may include wheels for easy transport.

[0019] The structure may be large enough to accommodate a plurality of individuals both before and after each individual takes a plurality of displacement steps.

[0020] The structure, display and real object may cooperate to create the environment of a room.

[0021] The structure, display and real object may cooperate to create the environment of a building having a plurality of rooms.

[0022] The structure, display and real object may cooperate to create the environment of a land, sea or air vessel.

[0023] The interactive environment may include a computer-controlled sensory generator, other than a display, configured to controllably generate matter or energy that is detectable by one or more of the human senses. The processing system may also be in communication with the generator and configured to control the generation

of such matter or energy. The processing system may be configured to control the generator as a function of the interaction between the individual and the scene.

[0024] The generator may include sound-generating apparatus.

[0025] The generator may include movement-generating apparatus. The movement generating apparatus may include floor movement generating apparatus. The movement generating apparatus may include air movement generating apparatus.

[0026] The generator may include a light.

[0027] The generator may include temperature-changing apparatus.

[0028] One or more images may be stereoscopic images. The display may be configured to display the stereoscopic images.

[0029] A distributed interactive environment may be partially real and partially simulated.

[0030] The distributed interactive environment may include a first computer-controlled display fixedly positioned within a first scene such that each image on the first display appears to a first individual in the first scene to be real, three-dimensional and an integral and seamless part of the first scene. A first sensor may be configured to sense interaction between the first individual and the scene.

[0031] The distributed interactive environment may include a second computer-controlled display fixedly positioned within a second scene such that each image on the second display appears to a second individual in the second scene to be real, three-dimensional and an integral and seamless part of the second scene. The second scene may be substantially the same as the first scene, but separated geographically from the first scene. A second sensor may be configured to sense interaction between the second individual and the second scene.

[0032] The distributed interactive environment may include a processing system in communication with the first and second displays and the first and second sensors. The processing system may be configured to deliver a sequence of images to the first display, the content of which are a function of the interaction between the second individual and the second scene. The processing system may also be configured to

deliver a sequence of images to the second display, the content of which are a function of the interaction between the first individual and the first scene.

[0033] A modular, interactive environment may include a set of modular walls that releasably connect to and disconnect from one another to facilitate the assembly, disassembly, shipment and re-assembly of the interactive environment in various different configurations. At least one of the walls may be a computer-controlled display configured such that images on the display appear to an individual within the environment created by the walls to be real, three-dimensional and an integral and seamless part of the environment. At least one sensor may be configured to sense interaction between an individual and the environment created by the modular walls. A processing system may be in communication with the sensor and the display and configured to deliver images to the display that vary based on the interaction between the individual and the environment.

[0034] These, as well as other objects, features and benefits will now become clear from a review of the following detailed description of illustrative embodiments and the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0035] FIG. 1 is an interactive environment that is partially real and partially simulated.

[0036] FIG. 2 is a lateral perspective view of the display wall shown in FIG. 1 with a real door in front of it.

[0037] FIG. 3 is a lateral perspective view of the display wall shown in FIG. 1 with a real window in front of it.

[0038] FIG. 4 is an interactive environment that is partially real and partially simulated of a different configuration.

[0039] FIG. 5 is a distributed interactive environment that is partially real and partially simulated.

[0040] FIG. 6(a)-(c) are configurations of other interactive environments that include vessels.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0041] FIG. 1 is an interactive environment that is partially real and partially simulated.

[0042] As shown in FIG. 1, a structure **101** may include real walls **103** and **105**. These may be constructed from props used in movie sets, i.e., from material that looks and acts like a wall, but is lighter, possibly thinner, and less expensive.

[0043] The structure **101** may also include display screen walls **107** and **109**. Display screen walls **107** and **109** may be configured to look like walls, as illustrated in FIG. 1.

[0044] The walls **103**, **105**, **107** and **109** may be configured so as to create the appearance of a room. The room may be large enough to accommodate an individual **111** both before and after the individual **111** takes a plurality of steps displacing himself horizontally, vertically or in some other direction.

[0045] At least one real, three-dimensional object may be positioned within the structure **101**, such as a desk **113** and a table **115**. The real objects may cooperate with the structure **101** to form a seamless and integrated scene from the perspective of the individual **111**.

[0046] The interactive environment may include one or more computer-controlled displays. In FIG. 1, two such computer-controlled displays are illustrated. One is a projector **117** directed toward the display screen wall **109**. The other is a projector **119** directed toward the display screen wall **107**. Each of these make up a rear-projection display. In each case, the display screen wall may consist of or include an opaque surface that radiates a quality image on the surface opposite of the surface that is illuminated by its associated projector.

[0047] Each computer-controlled display may be fixedly positioned relative to the structure **101** such that the display does not move during movement of the indivudal **111**. Indeed, each computer-controlled display or, as shown in FIG. 1, a portion of the display may be part of the structure, as illustrated by the display screen walls **107** and **109** forming walls of the structure **101**.

[0048]   The computer-controlled display or displays may be configured and positioned so as to appear to the individual **111** as an integrated and seamless part of the scene that is created by the structure and real objects. This part of the scene may be something other than a display, such as the walls illustrated in FIG. 1.

[0049]   The scene created by the structure **101** and the real objects **113** and **115** may be augmented by other real objects to enhance the realism of the scene to the individual **111**. These other real objects may cooperate with the scene so to form a seamless and integrated part of the scene, again from the perspective of the individual **111**.

[0050]   One such other real object may be a real, operable door **121**, a reference intended to also include the frame of the door. This may provide the individual **111** with a mechanism for entering the room that has been created and to enhance the realism of that room.

[0051]   A still further real object may be a real, operable door **123**, a reference intended to also include the frame of the door. This door may be positioned immediately in front of the display screen wall **107**, forming a seamless and integrated part of the scene from the perspective of the individual **111**.FIG. 2 is a lateral perspective view of the display screen wall **107** shown in FIG. 1 with the real door **123** in front of it. The real door **123** is operable and thus may actually be opened by the individual **111**, it being shown in open positions in both FIGS. 1 and 2. When the individual does open the door, the portion of the display screen wall **107** that lies behind the door may then becomes viewable to the individual **111**. If, as described in more detail below, an image of a scene **227** is projected on the portion of the display screen wall **107** that is behind the door **123** by the projector **119**, the individual **111** will see that scene and perceive it to be an integrated and seamless part of the scene that is created by the structure **101** and the real objects **113, 115** and **123**. Of course, the individual **111** may not actually be able to step through the real door because of the display screen wall **107** behind it.

[0052]   Returning to FIG. 1, a still further real object may be real window **125** placed in front of a display screen wall, such as the display screen wall **109**. Again, the real

window **125** may be constructed and positioned with respect to the structure **101** and the other real objects so as to be seamlessly integrated within the scene, again from the perspective of the individual **111**. And again, the individual **111** may not actually be able to extend a hand through the window **125** because of the display screen wall **109** behind it.

[0053] FIG. 3 is a lateral perspective view of the display screen wall **109** with the real window **125** in front of it. As shown n FIG. 3, the real window **125** may include real shutters **327**, each of which may include adjustable louvers **329** and pull knobs **331**. Similar to the door **123**, the individual **111** will see images projected by the projector **117** on the portions of the display screen wall **109** that are directly behind the window **125** if the individual **111** opens a shutter by pulling on its knob **131** or adjusting its louvers **129**.

[0054] Returning to FIG. 1, the interactive environment may also include one or more sensors, such as the sensor **127**. The sensors may sense interaction between the individual **111** and the scene by detecting and/or measuring that interaction.

[0055] The interaction that the sensors detect or measure may precede the several displacement steps of the individual, may follow those steps, or may occur during the steps. Indeed, the interaction that is sensed may be the steps themselves.

[0056] The sensors may sense movement of the individual. In this case, the sensor could be a camera and associated signal interpretive system, an ultrasonic sensor, a UV sensor, or any other type of movement sensing device. The individual could also be instrumented with the movement sensor, such as a GPS receiver and an associated transmitter for transmitting the extracted coordinate information.

[0057] The sensors may sense contact of the individual with an object in the scene or proximity of the individual to that object. For example, the sensors might detect that a door or window has been opened or that a gun has been shot. In the gun shot example, the sensors might include a sensor on the portion of the display screen wall **107** that is behind the door **123** that sensors the location at which a laser beam intersects that portion of the screen. The sensors might include a sensor attached to a laser gun (not shown) that is held by the individual **111** that senses the location of the

laser gun in three dimensional space. Using well-known triangulation techniques, the aim of the laser can then be computed from the information provided by these two sensors, followed by a determination of whether a particular target that might be a part of the image behind the door **123** has been hit.

[0058] The sensors may be configured to sense sound that is generated by the individual, such as by his voice or foot movement.

[0059] The sensors may be configured to sense the level of lighting in the room set by the individual **111** and hence the anticipated visibility of the individual **111** through a window or door opening.

[0060] The sensors may be configured to sense any other type of interaction between the individual and the scene.

[0061] Although a single sensor **127** is shown as being located in the corner of the structure **101** in FIG. 1, this is just to illustrate one example. Both the number and location of the sensors may vary widely, as suggested by the discussion above.

[0062] A processing system **131** may be included and configured to be in communication with the projectors **117** and **119** and the sensors, such as the sensor **127**. The processing system **131** may also be in communication with an image storage system **133**. The processing system **131** may also be in communication with a source of real-time image information over a communication link **135**.

[0063] The processing system **131** may be configured to select and deliver appropriate images to the projectors **117** and **119** from the image storage system **133** and/or the source of real-time imagery over the communication link **135**. The processing system **131** may be configured to cause the imagery that is selected to be delivered to the projector **117** and/or **119** to be a function of the interaction between the individual and the scene, including the plurality of displacement steps taken by the individual, as detected and/or measured by the sensors, such as the sensor **127**. In this configuration, the sequence of images that is delivered to the projector **117** and/or the projector **119** are considered to be "non-linear" because the sequence is not wholly

pre-determined, but rather a function of the interaction between the individual **111** and the scene, as detected by the sensors, such as the sensor **127**.

[0064] The configuration that has thus-far been described in connection with FIG. 1 provides a broad variety of flexibility and associated effectiveness in the interactive environment that is simulated.

[0065] In connection with a military training exercise, for example, all of the louvers **329** in the shutters **327** in the window **125** may be in the closed position with the individual **111** standing by the real desk **113**. The individual **111** may then walk over to the window **125** and open the louvers **329** on one of the shutters **327**.

[0066] This opening may be detected by a sensor (not shown in FIG. 1). Upon this detection, the processing system **131** may be programmed to select a video of a sniper moving in position to fire from the library of images on the image storage device **133**. It may also be programmed to deliver this image to the projector **117** such that this video is seen by the individual **111** while looking through the open louvers **329** in one of the shutters **327** in the window **125**.

[0067] The individual **111** may then raise a laser gun (not shown), point it toward the virtual sniper, and fire. This interaction between the individual **111** and the scene may be sensed by other sensors, including the direction that the gun was fired. The processing system **131** may then compute whether the direction of the firing was sufficiently accurate to immobilize the sniper.

[0068] To do this, the processing system may need information about the location of the sniper. This information might be developed from the image supplied by the image storage system **133** or from independent data that is supplied along with this image or as part of it.

[0069] If the processing system **131** determines that the aiming was sufficiently accurate to immobilize the sniper, the processing system **131** may then a video of the sniper falling to the ground select from the image storage system **133** and deliver that image to the projector **117**, thus communicating to the individual **111** that his firing was successful.

[0070] On the other hand, if the aim was not accurate, the processing system **131** might select a different image from the image storage system **133**, such as an image of the sniper firing back. Information from the sensors about the exact location of the individual **111** may then be delivered to the processing system **131** at the moment that the sniper fires, thus enabling the processing system **131** to compute whether the individual was successful in moving out of the way in sufficient time. The determination of this computation by the processing system **131** may be communicated to the individual **111** or to others as part of the training or assessment of the individual **111**.

[0071] As noted above, the display screen walls **107** and **109** may be large enough to appear to the individual **111** as an entire wall. In this configuration, the processing system **131** may be configured to deliver to the projectors **117** and **119** imagery of the desired interior texture of the walls **107** and **109**, such as the appearance of bricks. This would cause the display screen walls **107** and **109** to appear to the individual **111** as real, brick walls.

[0072] Of course, the imagery that the individual **111** sees through the door **123** and the window **125** would most likely be different. To accomplish this, the image that is stored in the image storage system **133** may actually consist of two images, the image of the textured area of the walls outside of the door **123** and window **125** and the virtual scene image that needs to appear in the portals of the door **123** or window **125**.

[0073] Alternatively, an overlay system may be used to overlay the images that should be seen in the portals on top of the texture images that appear around these portals. The needed texture could be separately stored as an image, such as in the image storage system **133**. A single sub-area of the needed texture might instead be stored and replicated by the processing system **131** in the needed areas.

[0074] Of course, other imagery could be projected on the portions of the walls outside of the portals created by the door **123** and the window **125**. For example, a video of a tank breaking through the wall might be projected in appropriate circumstances.

[0075] A broad variety of images may be delivered to the displays. They may include still pictures, videos, or a mixture of still pictures and videos. The images may be

virtual images generated by a computer or real images. They may be stored in electronic format, such as in a digital or analog format. They may also be optically based, such as from film.

[0076]   The images may be such as to appear to be real, three-dimensional and seamlessly integrated into the scene when displayed from the perspective of the individual **111**.

[0077]   By combining all these features, an individual can effectively walk or run in the simulated environment and interact with real and virtual components in the environment, just as though all of the components were real. This effectively creates a mixed reality world where the real and virtual are integrated and seamless co-exist.

[0078]   The scene that is created by these components, including the structure **101**, the display screen walls **107** and **109**, the real objects **113**, **115**, **123** and **125**, and the images that are delivered to the display screen walls **107** and **109** may cooperate to simulate a real environment, such as the real environment **145** shown in Fig. 1. In this situation, the structure **101** and the real objects may be selected and configured to substantially match the corresponding components in the real environment **145**, as shown by the inclusion in the real environment **145** in Fig 1 of similar-looking corresponding components.

[0079]   Similarly, the images that are delivered to the display screen walls **107** and **109** may mimic what the individual **111** would see if he were in the real environment and had been interacting with the real environment as the individual **111** is interacting with the simulated environment.

[0080]   To accomplish this, photographs and videos of the real environment may be taken and used in the construction of the simulated environment and in the creation of the library of images that are stored in the image storage system **133**.

[0081]   It may also be possible to position cameras in the real environment, such as cameras **141** and **143** in the real environment **145**. The camera **141** may be pointed in the very direction of the imagery that the projector **117** may be directed by the processing system **119** to project in the opening of the window **125**. Similarly, the

camera **143** may be pointed in the very direction of the imagery that the projector **119** may be directed by the processing system **131** to project on the opening in the door **123**. The signals from the cameras **141** and **143** may be delivered to the processing system **131** over the communication link **135**, as also shown in FIG. 1.

[0082] A computer-controlled sensory generator **151** may also be included in association with the structure **101**. Although illustrated as a single device in the corner of the room, it is to be understood that the sensory generator **151** may, in fact, be several devices located at various locations.

[0083] The sensory generator **151** may be configured to controllably generate matter or energy that is detectable by the human senses, such as by the human senses of the individual **111**. The processing system **131** may be in communication with the sensory generator **151** so as to control the sensory generator to add additional realism to the simulated environment. The control of the sensory generator may be a function of the interaction between the individual **111** and the scene, as sensed by the sensors, such as the sensor **127**.

[0084] The sensory generator **151** may include sound-generating apparatus, such as immersive audio systems and echo-generating systems. These can replicate the sounds that the individual **111** would expect to hear from the images that are being projected on the display screen walls **107** and **109**, such as gunfire, thunder, voices, the rumbling of a tank, and the whirling of a helicopter blade.

[0085] The sensory generator **151** may also include movement-generating apparatus, such as devices that shake the walls or floors of the structure **101**, again to reflect what might be expected to be felt from many of these projected images.

[0086] The movement-generating apparatus may also move objects in the room, such as causing pictures on a wall to fall, glass to break, or even the floor to move violently to simulate an earthquake.

[0087] The movement-generating apparatus may also cause air to move, such as to simulate wind.

[0088]   The sensory generator **151** may also generate particulate material, for example, droplets simulating rain or a mist simulating fog.

[0089]   The sensory generator **151** may also include one or more lights, such as one or more strobes to assist in the simulation of lightning or an explosion.

[0090]   The sensory generator **151** may also include temperature changing apparatus so as to cause temperature changes, providing even further flexibility in the types of environments that may be simulated.

[0091]   The components that interact together to create the interactive environment may be designed in the form of modules. The same set of modules may be used to create a vast variety of different types of simulated environments.

[0092]   The use of projected wall textures may be particularly helpful by allowing the same display screen wall to be used with different projected images, so as to create the virtual appearance of a broad variety of different types of walls.

[0093]   The modules may also be fitted with releasable connections so that one module may be readily attached to and detached from another module. This may facilitate the ready assembly, disassembly, packaging, shipment and reassembly of a broad variety of simulated environments from the same set of modules.

[0094]   As is well known in the art, a broad variety of connection systems may be used to implement this releasable function. Such systems include latching mechanisms and deformable male projections and female receptacles that allow modular-like components to be easily snapped or slid together and just as easily snapped or slid apart. Traditional fasteners, such as nuts and bolts, may also be used.

[0095]   The size of each modular component may also be kept to a specified maximum. If this is exceeded by the needed size of a large wall, the large wall may be made up by releasably connecting a set of smaller wall segments.

[0096]   Heavy pieces may also have wheels placed along their bottom edge, such as wheels **231** shown in FIG. 2 or wheels **341** shown in FIG. 3, to make it easier to relocate them.

[0097] FIG. 4 illustrates an interactive environment that is partially real and partially simulated of a different configuration. As shown in FIG. 4, the interactive environment includes rooms **401**, **403**, **405** and **407**, each with associated windows **409**, **411**, and **413** and **421** and doors **415**, **417**, **419** and **421**. Display screen wall **423**, **425**, **427**, **429** and **430** may also be included and, in conjunction with projectors **431**, **433**, **435**, **437** and **439**, may make displays of the type discussed above.

[0098] The specific details of this embodiment may follow one or more of the details discussed above in connection with FIGS. 1-3. When constructed out of the type of modular components discussed above, the simulated environment in FIG. 4 can be easily and quickly constructed out of these very same components and with no added expense. This illustrates the great flexibility and power of the modular system

[0099] FIG. 5 illustrates a distributed, interactive environment that is partially real and partially simulated. As shown in FIG. 5, a first structure **501** may include a display screen wall **503**, a real window **505** and a desk **507**. An individual **509** may be within the structure **501**. The interaction between the individual and the scene created by the structure **501** and its associated real objects may be sensed by a sensor **511**. A projector **513** may be directed to the display screen wall **503** creating in combination with the display screen wall a computer-controlled display.

[0100] A second and complementary environment may include a complementary set of components, including a second structure **525**, desk **527**, real window **529**, projector **531**, display screen wall **533** within the window **529** and sensor **535** configured to sense the interaction between a second individual **537** and the environment created by the second structure **525** and its associated components.

[0101] A processing system **515** may be in communication with the projectors **513** and **531** and the sensors **511** and **535**.

[0102] The configuration shown in FIG. 5 can be useful in training or testing a group of individuals, without requiring the group to be at the same location.

[0103] All of the individuals may interact with the same mixed reality environment. In this situation, all of the corresponding components between the two environments may

be the same or substantially the same, to the extent possible. Although only two distributed environments and two individuals have been shown in FIG. 5, it is to be understood that a different number of either or both could also be used.

[0104] All of the components shown in FIG. 5 may be configured to operate as described above in connection with the components shown in FIGS. 1-4. To accomplish interaction, however, the processing system **515** may be configured to cause images that are sent to the projector **513** to be a function of the interaction between the second individual **537** and the scene he is associate with, as detected and/or measured by the sensors **535**. Similarly, the sequence of images that the processing system **515** delivers to the projector **531** may be a function of the interaction between the first individual **509** and the scene with which he is associated, as detected by the sensors **511**. The processing system **515** may also take into consideration the signals generated by the sensor that is in the same scene as the projector in selecting the image to be displayed in that scene.

[0105] One application of this distributed environment is the sniper example discussed above. Instead of the sniper being a wholly virtual image, however, that sniper may actually be the real individual **537** shown in FIG. 5. As can readily be imagined, the processing system **515** may cause an image of the first individual **509** to be projected on the screen display **533**, creating a virtual target for the second individual **537**. Conversely, the processing system may cause an image of the second individual **537** to be cast upon the display screen wall within the portal of the window **505**, creating a target for the first individual **509**. As each of the individuals react to their respective targets, the interaction between the individuals and their scene can be detected and/or measured by the sensors **511** and **535**, respectively, causing the processing system **515** to appropriately adjust the next set of images that are delivered to the display being viewed by each individual. Because of the seamless integration of real and virtual components in each environment, the mixed reality systems may provide the illusion to each individual of a completely real environment.

[0106] The images that are delivered to the projectors 513 and 531 may be synchronized in some manner to one another, such as the delivery of identical images

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being delivered to both projectors. The selection and/or the timing of the images may also be a function of a stimulus other than or in addition to the stimulus detected by the sensors **511** and **535**. For example, the stimulus could be a signal from a trainer that is monitoring an interactive environment that is configured for training that initiates the simulation of an explosion.

[0107] Although one or more rooms have thus-far been illustrated as the structure of the environment, it is to be understood that a broad variety of different structures can be created and operated using the same principles. These include buildings with multiple floors and multiple rooms, geographic areas that contain several buildings, alleyways, streets and associated structures, and vessels, such as the ship, plane or freight truck shown in FiGs. 6(a), (b) and (c), respectively.

[0108] Although only a single individual has thus-far been shown in each structure, it is to be understood that each structure could be large enough to accommodate a plurality of individuals, both before and after each takes several displacement steps, either horizontally, vertically or in some other direction. The structures may even be large enough to allow the individuals to walk many steps or to even run.

[0109] Although certain real objects have thus-far been illustrated to enhance the realism of the scene, it is to be understood that other real objects could also be used, such as pictures, floors, fans, lighting, carpeting, bookshelves, wallpaper and ceilings. All of the real objects may also be part of the modular system discussed above, making them easy to assemble, disassemble, transport and reassemble.

[0110] Although only rear-projection displays have thus-far been illustrated, it is to be understood that any type of display can be used, including front projection displays and flat displays, such as large plasma displays and electronic ink devices.

[0111] The image that is delivered to a display may also be a stereoscopic image suitable for generating a three-dimensional effect. The display that receives this image may also be one that is suitable for displaying the stereoscopic image so as to create the three-dimensional effect. The image that the individual views within the scene may then appear to change in perspective as the individual changes her position relative to the display, thus adding to the realism. The individual may wear appropriate 3-D

glasses to realize this effect or, in connection with emerging 3-D technologies, wear nothing additional at all.

[0112] The partially real and partially simulated modular interactive environment that has thus-far been described may be used in connection with a broad variety of applications, including simulations of military operations, architecture and interior design. It may be used in connection with theatrical presentations, location-based entertainment, theme parks, museums and in training and testing situations. Other applications are also embraced. The position of each display screen wall, such as the display screen walls **107** and/or **109,** may be adjusted to precisely match the position that the walls need to be in so that the image they project is correctly located in the scene that the walls help to create. The image that is projected on each display screen wall, including its perspective, may additionally or instead be adjusted by the processing system to effectuate the same result.

[0113] To help in this process, one or more additional sensors may be provided to sense the position of one or more of the display screen walls. Such sensors may or may not be attached to the display screen walls and may be optical, magnetic, utilize the GPS system, or may be of any other type. The information provided by these sensors may then be used to help position the walls precisely and/or to cause the image that is projected on them to be adjusted by the processing system, as discussed above.

[0114] Although certain embodiments have now been described, it is to be understood that the features, components, steps, benefits and applications of these technologies are not so limited and that the scope of this application is intended to be limited solely to what is set forth in the following claims and to their equivalents.